

I – Problem Statement Title (EQ 086)

**Development of Fragility Curves for Liquefaction Screening of
Caltrans Bridge Structures**

II – Research Problem Statement

Question: How can Caltrans' 12,000+ bridge structures be screened for vulnerability to liquefaction in an efficient and accurate manner?

Only a relatively small percentage of Caltrans bridge structures have been evaluated for susceptibility to liquefaction-induced damage. Although geotechnical assessment of potential ground displacement is the primary factor in considering liquefaction hazard, of considerable importance is a structure's tolerance for footing and abutment offset. It is conceivable, for example, that many bridges at locations identified as capable of producing large ground displacements are of a type that are tolerant of such displacements (from a collapse standpoint) and may not warrant remediation. On the other hand, some structural types may prove particularly vulnerable to even small displacements. Fragility curves that identifies tolerance for footing and abutment displacement is needed. These curves would then be applied in conjunction with a geologic/geotechnical hazard level (probabilistic approach) or an earthquake magnitude (deterministic approach) as part of a rational liquefaction screening program. (The proposed project is a companion proposal to a separate PEER-LL proposal to screen Caltrans bridges for liquefaction risk based on geologic criteria.)

III – Objective

STAP Roadmap Outcome: 6

The objective of this research (and its companion proposal) is to perform parametric studies focusing on screening Caltrans bridges of different vintage for liquefaction hazard. This proposal would develop fragility curves that can be used to evaluate a structure's tolerance for ground displacement. Development of the fragility criteria will be based on evaluation of case histories of liquefaction-induced collapses as well as some simple numerical studies. These criteria will be combined with the geologic based vulnerability developed in the companion study to provide a combined vulnerability ranking.

IV – Background

Caltrans has over 12,000 bridge structures in its inventory. During the seismic retrofit program bridge structures were screened for possible retrofit based on structural criteria only. Those bridges that were ultimately adopted into the retrofit program (approximately 3000) were ultimately analyzed for liquefaction susceptibility and many incorporated

liquefaction mitigation into the ultimate retrofit strategy. Bridges that did not meet retrofit screening criteria based on structural considerations, however, never received liquefaction screening. The extent of mitigation of liquefaction hazard needs to be determined to enable potential programming of these bridges in STRAIN.

V – Challenge Area/Statement of Urgency and Benefits

Challenge Area: Earthquake Engineering, Improved Post-Earthquake Bridge Serviceability, Reduced Construction Costs, Improved Structural Design Methods, Enhanced Materials/Systems Technology, Enhanced Design Specifications for Improved Structural Performance

Past earthquakes have shown liquefaction to be one of the causes of damage that may lead to a bridge collapse. Much of California is vulnerable to earthquake ground motion large enough to trigger the on-set of liquefaction. Given Caltrans' policy of "no collapse" seismic performance, development of tools for structural/soil liquefaction screening of Caltrans' bridge inventory should be considered high priority.

VI – Related Research

Knudsen, K, Rosinski, A, Wiegers, M., Real, C., Wu, J., Seed, R. (2004). "Investigation of Methods to Produce Regional Maps of Liquefaction-Induced Deformation: A Pilot Study", Pacific Earthquake Engineering Research Center Report No. TBA October, 2004

VII – Deployment Potential

The screening methodology and fragility curves developed in the proposed project will be deployed to facilitate screening Caltrans' 12,000+ bridges for liquefaction risk.